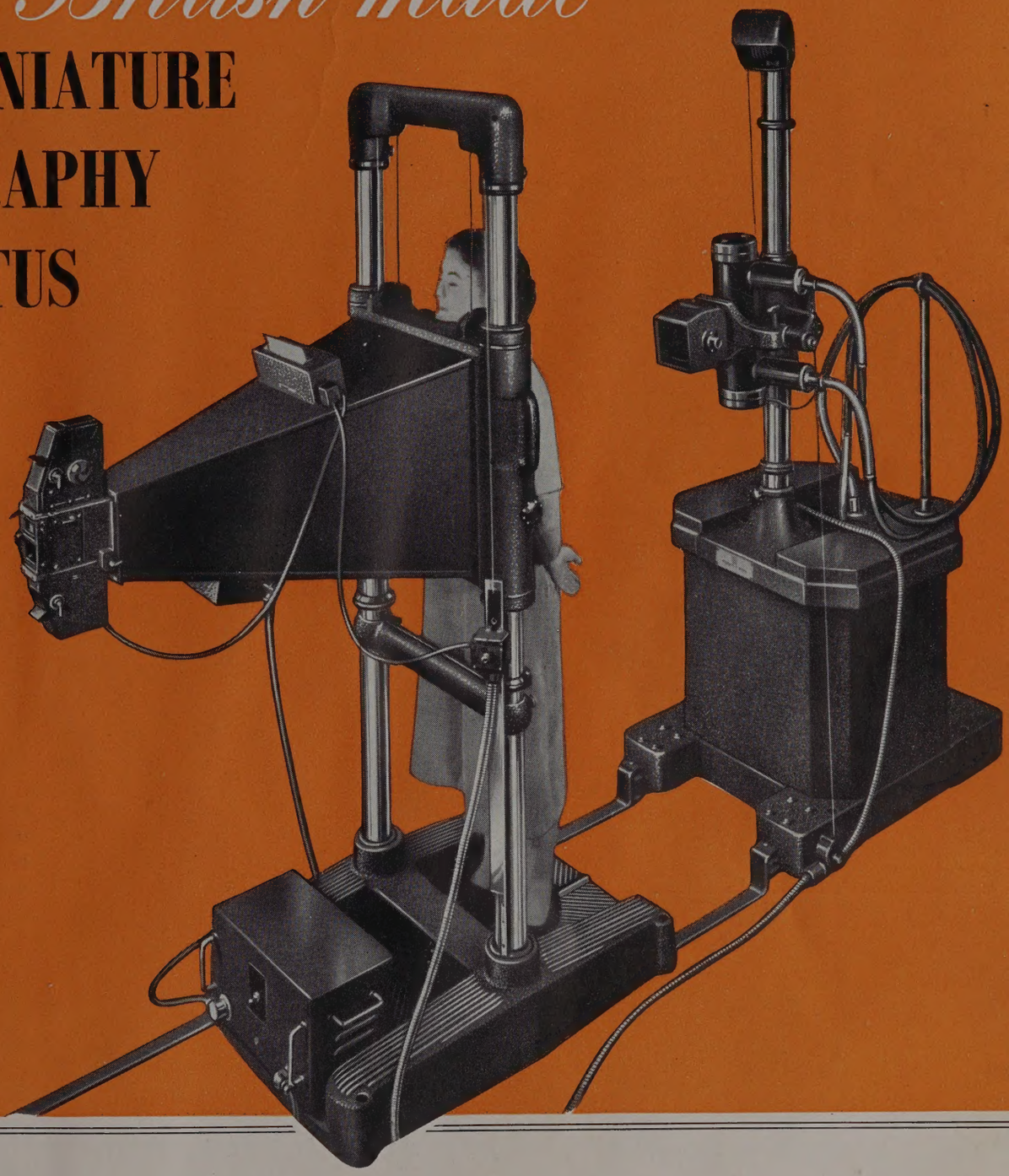
PUBLICATION Nº 317

WATSON

British made

MASS MINIATURE RADIOGRAPHY APPARATUS



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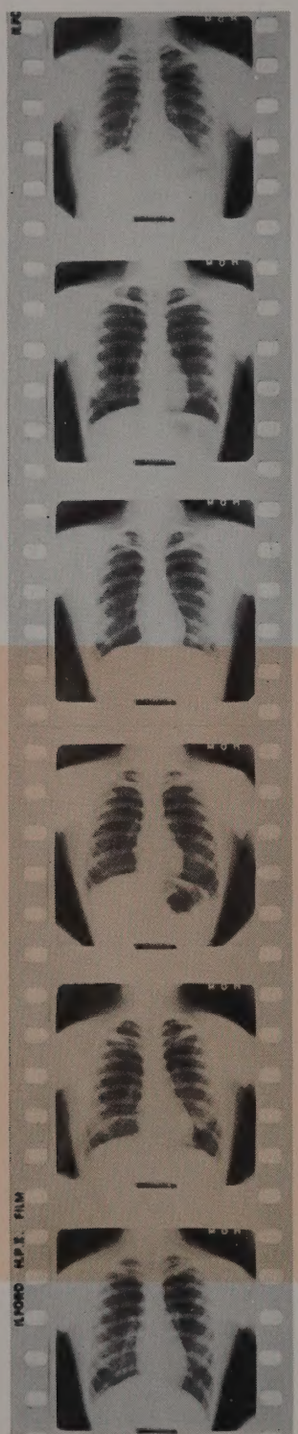
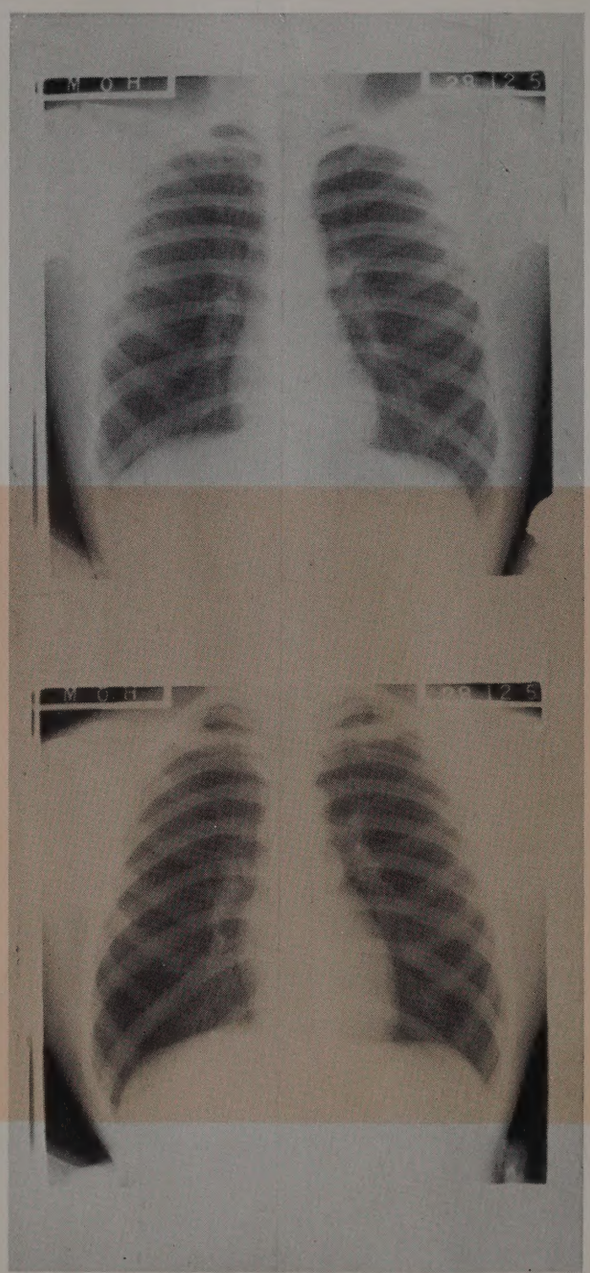
WATSON & SONS (ELECTRO-MEDICAL) LTD

Radiographs which reveal minimal lesions are essential to success in Mass Radiography



. . . the results obtained with WATSON equipment have been proved to meet this requirement.



These are actual size reproductions of radiographs taken with the Watson Mass Miniature Radiography Apparatus, that at the extreme left being 35 mm. film which is viewed by projection, and the other 70 mm. film for viewing directly or through a magnifier. These reproductions cannot do justice to the superlative quality of the miniature radiographs consistently produced by users. The apparatus also has facilities for taking full-size radiographs of the highest standard.

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MASS MINIATURE RADIOGRAPHY

Historical Note

In the years preceding the war, original research on mass miniature radiography was carried out simultaneously by several workers, notably de Abreu[1] in Rio de Janeiro, and Dormer and Collender[2] in South Africa. It was not, however, until the British Government, concerned by the increasing incidence of tuberculosis occasioned by living conditions in wartime, set in motion machinery to investigate the problem, that mass radiography on a large scale was considered in this country.

The Report[3] of the Committee appointed by the Medical Research Council to investigate the problem, included a strong recommendation for the adoption of mass radiography of the chest on a nation-wide scale. A technical sub-committee, set up to advise on the equipment to be used for the purpose, finally recommended a unit based upon specifications prepared, with their collaboration, by Watson & Sons (Electro-Medical) Limited. The first of these units was operated under close supervision by the Medical Research Council. It proved to be entirely successful, and the experience gained in its operation formed the basis for the recommendations issued to local health authorities[4].

Careful records were kept of the performance and general manipulative convenience of this first series of units, and as a result, technical improvements are incorporated in later series.

A measure of the success of the design can be gained from the knowledge that at the time of going to press, more than 9,000,000 men and women have been examined on Watson apparatus in England and Wales alone. Of these some 5% were recalled for large films and between three and four per thousand of all persons examined were found to have previously unsuspected active tuberculosis.

REFERENCES

[1] ABREU, M. DE, Radiology, 1939, Vol. 33, p. 363.

[2] DORMER, B. A., and COLLENDER, K. G., Lancet, 1939, Vol. 1, p. 1309.

[3] MEDICAL RESEARCH COUNCIL, Report of the Committee on Tuberculosis in Wartime. Special Report Series No. 246, H.M. Stationery Office.

[4] MEDICAL RESEARCH COUNCIL, Mass Miniature Radiography of Civilians. Special Report Series No. 251, H.M. Stationery Office.

EXTRACT from a

MINISTRY OF HEALTH MEMORANDUM

" The Medical Research Council's Committee on Tuberculosis in wartime advocated in their Report that:

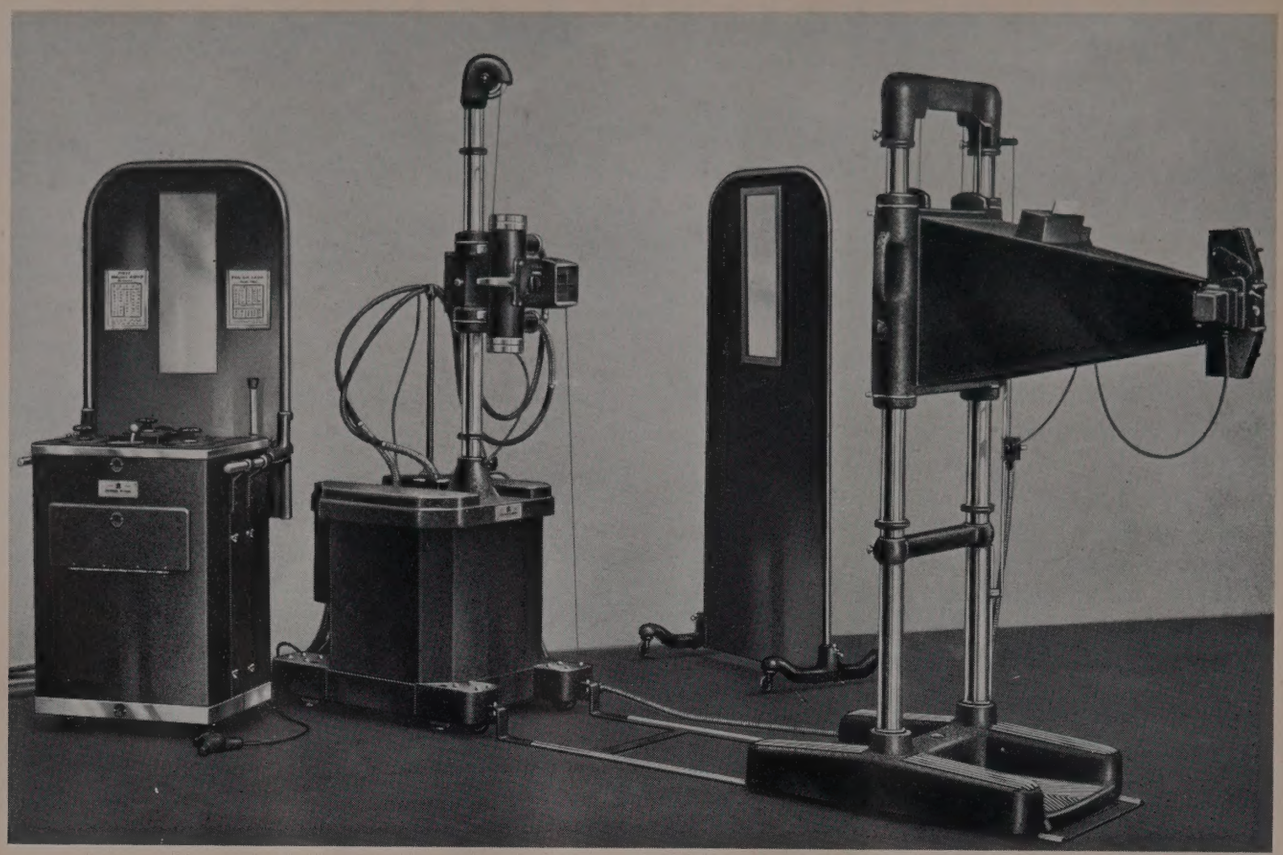
> **' Mass miniature radiography should not be lightly undertaken. A very high standard of quality of miniature radiography is necessary for correct interpretation, and the latter requires the highest radiological skill. The making-up of compromise apparatus cannot be too strongly condemned and would bring the method into disrepute.'**

" The Mass Radiography Sub-Committee of the Minister of Health's Standing Advisory Committee on Tuberculosis, in their report on the working of a mass radiography unit, said:

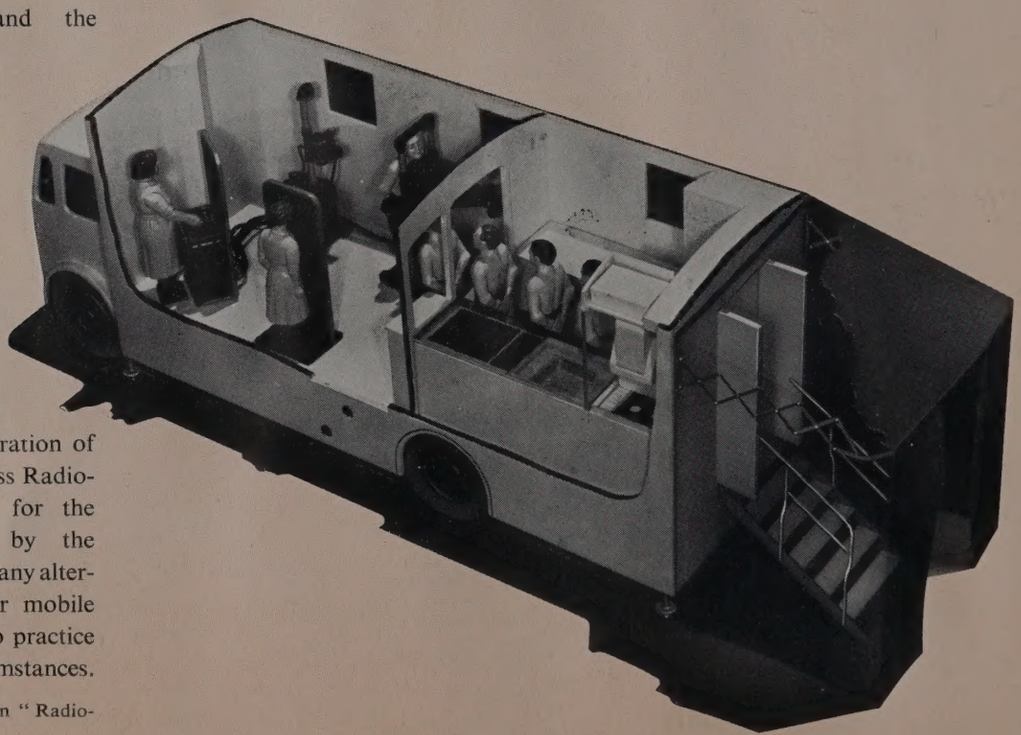
> **' When mass miniature radiography is to be undertaken on a large scale, trustworthy and comparable results can be secured only with the use of a carefully designed standard apparatus.'**

" In accordance with these authoritative views, the Government has made certain that the standard apparatus which they have arranged to be manufactured* is of the highest standard and able to meet the much greater stresses to which such a unit is subject compared with ordinary X-ray machines, and as far as possible immune from mechanical breakdowns."

*The standard apparatus mentioned here is that manufactured by Watson & Sons (Electro-Medical) Limited.



The complete apparatus is shown above: the Control Unit with Protective Screen, the Transformer Unit, the second Protective Screen, and the Camera Unit.



At the right is an illustration of a model of a mobile Mass Radiography Unit designed for the Ministry of Health by the Ministry of Works*. Many alternative arrangements for mobile units have been put into practice to suit various circumstances.

*The unit is fully described in " Radiography ", December, 1949.

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WATSON

APPARATUS FOR MASS MINIATURE RADIOGRAPHY

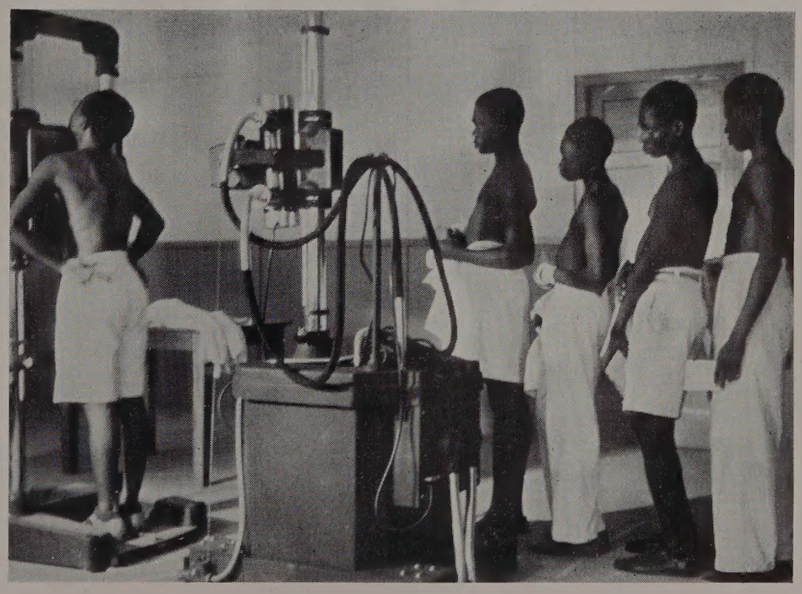
BRITISH PATENT Nos. 556705, 556883, 557050, 557150, 557831, 593352 and others.

THE prime consideration in mass miniature radiography of the chest, is the quality of the finished radiograph. This must be beyond criticism for on it depends the whole success of any mass radiography scheme.

It is a comparatively simple matter to construct an apparatus for taking miniature radiographs of reasonable quality, but a problem beset with immense technical difficulties to make one capable of producing without fail, many thousands of miniature radiographs each conforming to the critically high standard which is essential if the singling out of examinees with minimal foci of infection is to be successful. For this reason the design of the Watson apparatus for mass miniature radiography was approached as a scientific problem, and nothing has been overlooked which could in any way affect the quality of the radiographic result.

Speed in the handling of examinees is another of the essentials of a mass radiography unit. With the Watson apparatus exposures can be made in rapid succession without fear of overloading the tube or generator. In practice the pace is set by the time taken by the clerical staff in completing the examinee's record cards.

Of particular importance is the question of freedom from breakdown, for a mass miniature radiography apparatus should be capable of making as many exposures in a single day as an ordinary X-ray apparatus may make in several months. The requisite reliability is ensured by incorporating electrical interlocking devices which preclude the risk of the X-ray tube being overloaded and by the use of generous margins of safety in the design of all parts subjected to electrical or mechanical strain.



In many distant parts of the world Watson Mass Radiography Units are helping to combat tuberculosis. The photograph shows an installation in Lagos, Nigeria.

THE APPARATUS DESCRIBED

The apparatus is suitable for mass miniature radiography, direct (full size) chest radiography, and for the limited amount of fluoroscopy which may be necessary. It is designed for rapid assembly without the use of any tools, is readily transportable, and capable of operation from alternating current supplies of from 140–260 volts (under certain conditions from 100–120 volt supplies).

The apparatus consists of three main components—the Transformer Unit, the Camera Unit, and the Control Table which are described in detail below. The transformer unit and camera unit are linked together by a floor track (hinged for convenience in transport) engraved with a scale indicating the focus/screen distance and fitted with stops which automatically indicate the 3 ft. and 5 ft. positions. Vertical adjustment of the two units is automatically synchronized by a flexible linkage system.

Electrical connection between the mains supply, the transformer, and the control table is effected by means of leads enclosed in flexible metallic tubing. Multiple non-interchangeable sockets are provided at each end and are marked with numbers corresponding to those on the appropriate recessed plugs on the apparatus.

The construction conforms throughout to the recommendations of the British X-ray and Radium Protection Committee (Seventh Edition) as regards both X-ray and electrical protection. Two mobile protective screens are provided, one for the operator at the control table and the other for the radiographer responsible for positioning the examinees.

THE GENERATOR AND TUBE STAND UNIT

THE HIGH TENSION TRANSFORMER

This unit comprises the High Tension Transformer which serves also as a base for the Tube Stand.

The high tension transformer is a self-contained unit incorporating full wave (four-valve) rectification. It has a maximum output of 400 mA which is necessary, according to the foremost authorities, to obtain the best possible standard in direct (full size) chest radiography.

A wrought steel trolley mounted on castors supports the transformer. The function of the trolley is to facilitate rapid installation, provision being made for levelling the unit on uneven floor surfaces, and for locking it when it has been positioned.

THE X-RAY TUBE

A Machlett " Dynamax 25 " shockproof rotating anode tube is supplied. It has a dual focus with projected focal spot sizes of 1 and 2 mm.^{2} the larger focus being employed normally for both miniature and full size chest radiography. The thermal capacity of the tube is more than adequate to cope with the most severe operating and climatic conditions likely to be encountered, and it has proved to be capable of making many thousands of exposures without deterioration. An inbuilt exposure counter provides a valuable check on the operating life of the tube.

THE TUBE STAND

The tube stand affords a range of vertical tube movement from 43 to 60 in. (1.09 m. to 1.52 m.) above the examinee's platform.

The tube is supported by a tube stand of very rigid construction, with a spring counterpoise device which enables the tube to be positioned without effort.

Provision is also made for angulating the X-ray tube, the pivotal point being so arranged that the tube focus will remain at the same height irrespective of the angle of tilt.

ADJUSTABLE DIAPHRAGM

In order to cover the full range of work for which

the unit is designed, the focus/screen distance has been made variable from 30 in. (0.76 m.) (for screen examinations) to 60 in. (1.52 m.) (for direct radiography on full size films). To afford protection against unwanted radiation, an adjustable diaphragm is therefore provided to restrict the X-ray beam to the area of the fluorescent screen at all distances. This diaphragm provides three aperture sizes which will reduce the field of radiation to the sight size of the fluorescent screen at focus/screen distances of 36, 48, and 60 in. (0.91, 1.22, and 1.52 m.). The smallest aperture is used for fluoroscopy and reduces the area of screen illumination to 15 × 15 in. (38.1 × 38.1 cm.) at a distance of 30 in. (0.76 m.) thus leaving an appreciable margin around the screen to protect the operator against primary radiation.

The adjustable diaphragm is used, in addition, in conjunction with an optical centring device, to facilitate precise centring of the X-ray beam on the fluorescent screen when initially setting up the apparatus. Once the correct setting is obtained, it will remain correct for all tube and camera unit heights.

THE SCREENING AND CAMERA UNIT

The stand supporting the fluorescent screen and camera unit is mounted on a base having a system of grooved wheels which permit easy movement on the floor track for adjusting the focus/screen distance.

When the height of the fluorescent screen carriage is adjusted to the height of the examinee, the X-ray tube carriage also moves correspondingly so that the tube, once set up, remains accurately centred on the fluorescent screen at all heights. This is accomplished by the use of a new type of flexible linkage system (Patent) which operates equally well at all focus/screen distances.

The size of the screen is $16\frac{1}{2} \times 16\frac{1}{2}$ in. (42 × 42 cm.) and it is faced with lead-glass having a protective value equivalent to not less than 2 mm. of lead.

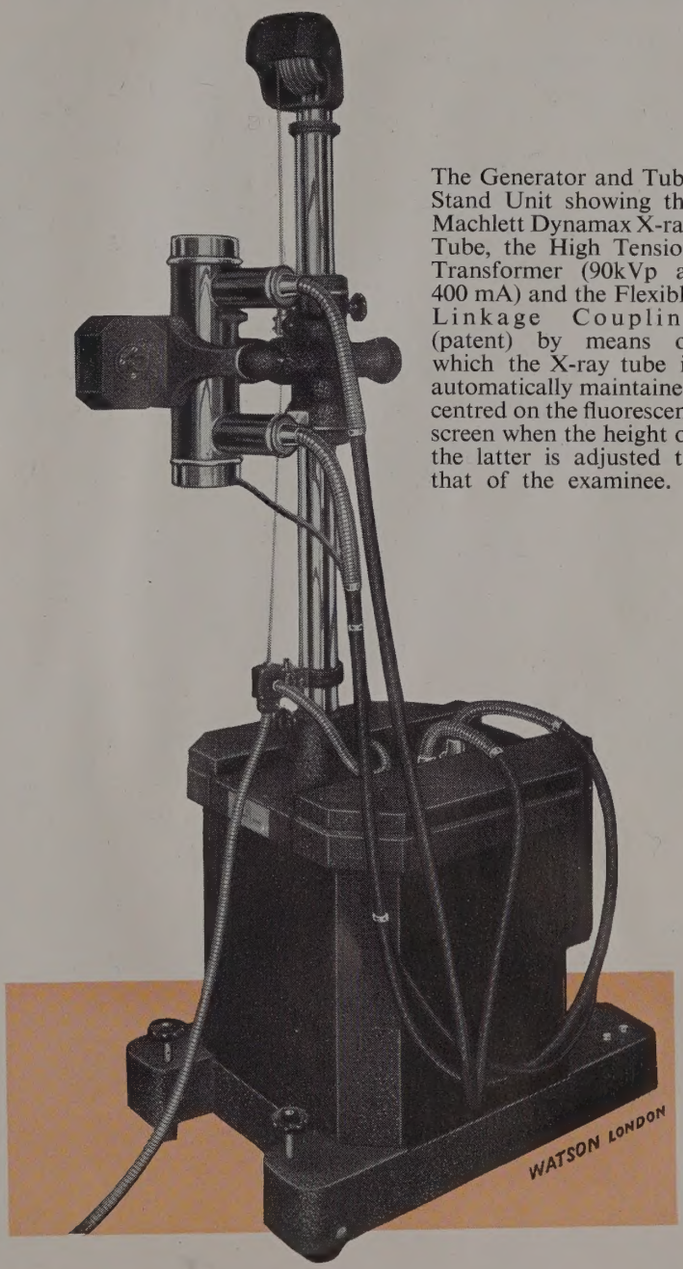
Secondary radiation from the patient is absorbed by a Watson "Lucidex" secondary radiation grid permanently fitted in front of the fluorescent screen. The use of this grid materially improves the quality of the radiographs, the lines being too fine to be discerned on the film. As it is the most ray-transparent grid yet devised, its use does not make necessary an undue increase in tube tension.

Lead numbers or figures indicating the unit number, date, or information of a similar character can be inserted in holders on the screen frame.

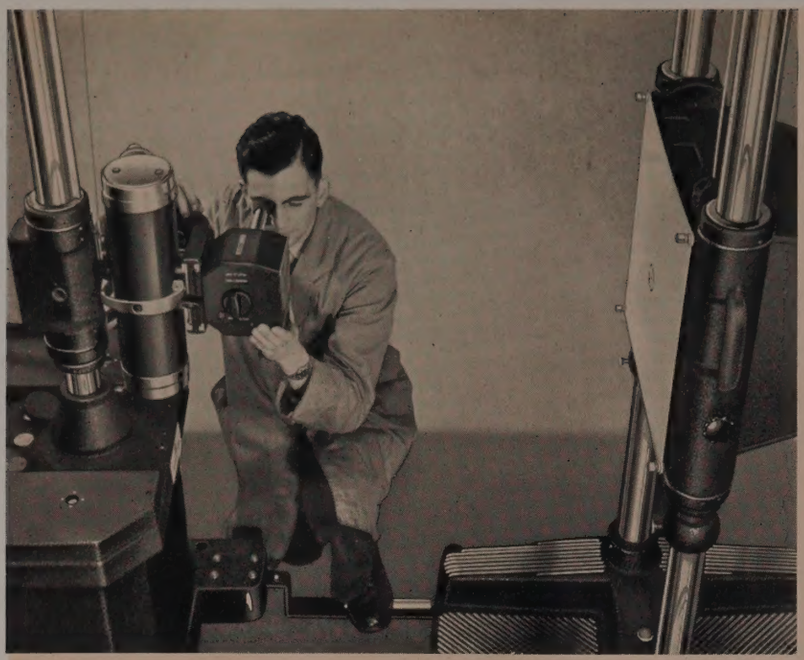
For use in direct (full size) radiography, a cassette tunnel is provided for attachment to the fluorescent screen unit. With the camera tunnel removed, it is thus possible to screen, and to place cassettes in the path of radiation without disturbing the position of the examinee.

THE CAMERA

Designed from first principles as an integral part of the unit, the camera is fully automatic in action, and constructed throughout at the Watson factory to

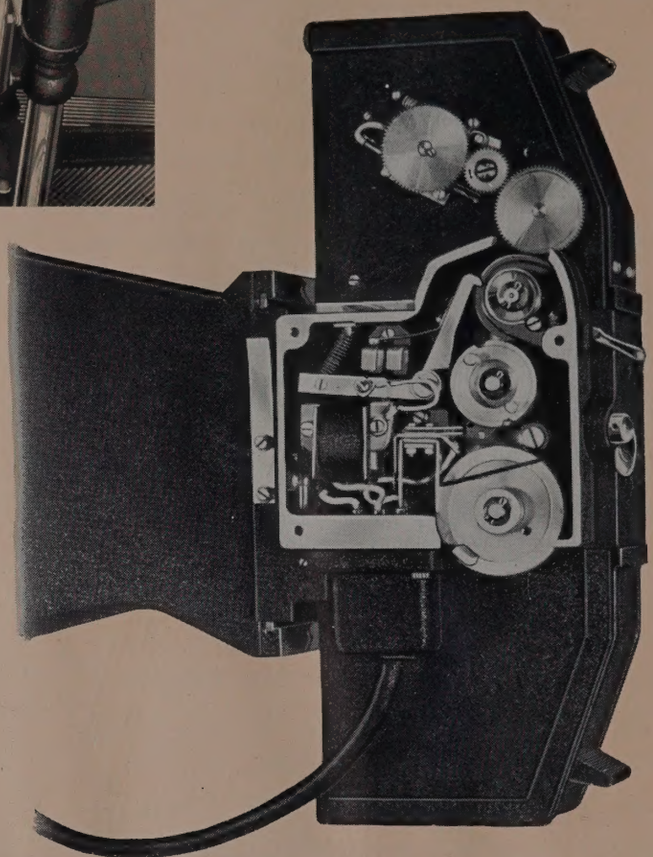


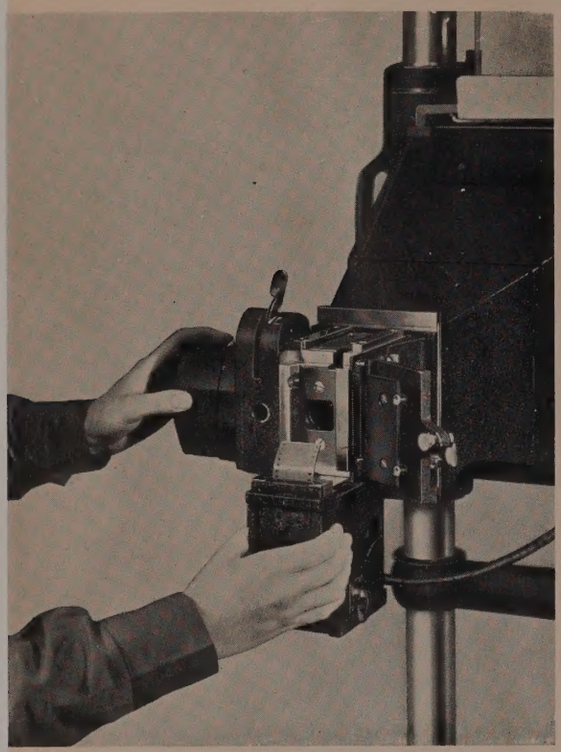
The Generator and Tube Stand Unit showing the Machlett Dynamax X-ray Tube, the High Tension Transformer (90kVp at 400 mA) and the Flexible Linkage Coupling (patent) by means of which the X-ray tube is automatically maintained centred on the fluorescent screen when the height of the latter is adjusted to that of the examinee.



Left. When the apparatus is set up, the X-ray tube is accurately centred on the fluorescent screen by means of the Optical Centring Device.

Below is a view of the Camera with part of the cover removed to show some of the mechanism. The Camera is fully automatic, the film being moved forward electrically when the exposure lever on the Control Table is operated.





Above. The Camera with the gate open, the exposed film cassette removed, and the unexposed film cassette being placed into position. Interlocking devices virtually preclude the possibility of incorrect operation.

Right. The 35-mm. camera is shown in its carrying case with a spare exposed film cassette. The other case contains a film marking outfit, delicate components, spare lamps, etc.

precision engineering standards which ensure that it will carry out the continuous and exacting work required of it in mass radiography. The features described below are common to the cameras for 35 mm. or 70 mm. film except where otherwise indicated.

The lens, which, with its focusing mount, is designed specially for miniature film radiography, is manufactured in England by Taylor, Taylor & Hobson and has an aperture of f/1.5 and 5 cm. focal length (11 cm. in the case of the 70 mm. model). The loss of light by reflection at the various air-glass surfaces (of which there are the minimum) is almost entirely eliminated by a non-reflective coating on all the internal and external air-glass surfaces. The speed of the lens is thereby increased by 30–40% and the quality of the films is substantially enhanced. As accurate focusing is of paramount importance, the lens is rigidly attached to the gate of the camera in such a way that the exact relationship between it and the film can be determined, and then set accurately to within a fraction of one thousandth of an inch. Once set, the lens will remain indefinitely at its predetermined position.

Each cassette has a capacity of 82 ft. (25 metres) of film, sufficient for some 720, 35 mm. radiographs or 320, 70 mm. radiographs. The exposed film cassette can be removed after any desired number of radiographs has been made, and replaced by an empty cassette (a spare is supplied) which can be recoupled to the film in daylight for a further series of radiographs. The film advances automatically by one frame at the termination of each exposure. After a predetermined number of exposures, the operator receives an indication in order that, if required, the film may be cut into suitable lengths for processing. Electrically interlocking contacts incorporated in the camera are so designed that an exposure cannot be made unless:

1. The gate is closed and the camera is otherwise ready for use.
2. Fresh film is in the gate.
3. The take-up spool has taken up the slack film.

The exposed film cassette incorporates a guillotine for shearing the film and, to ensure that the cassette is rendered light-tight and that the film is severed, the cassette cannot be removed until the guillotine has operated.

An indicator fitted to the unexposed film cassette shows the amount of unexposed film remaining. The cassettes cannot be accidentally opened when they are fitted in place on the camera. The method of fitting the spools to the camera avoids tensioning difficulties and ensures that the emulsion is not damaged.

All the bearings which lead to the inside of the camera are self-lubricating and no oiling is required throughout its life, thus preventing any possibility of the entrance of lubricating oil into the cassettes. The camera is made throughout from non-ferrous metals and stainless steel and is therefore immune to atmospheric conditions.

THE FILM NUMBERING DEVICE

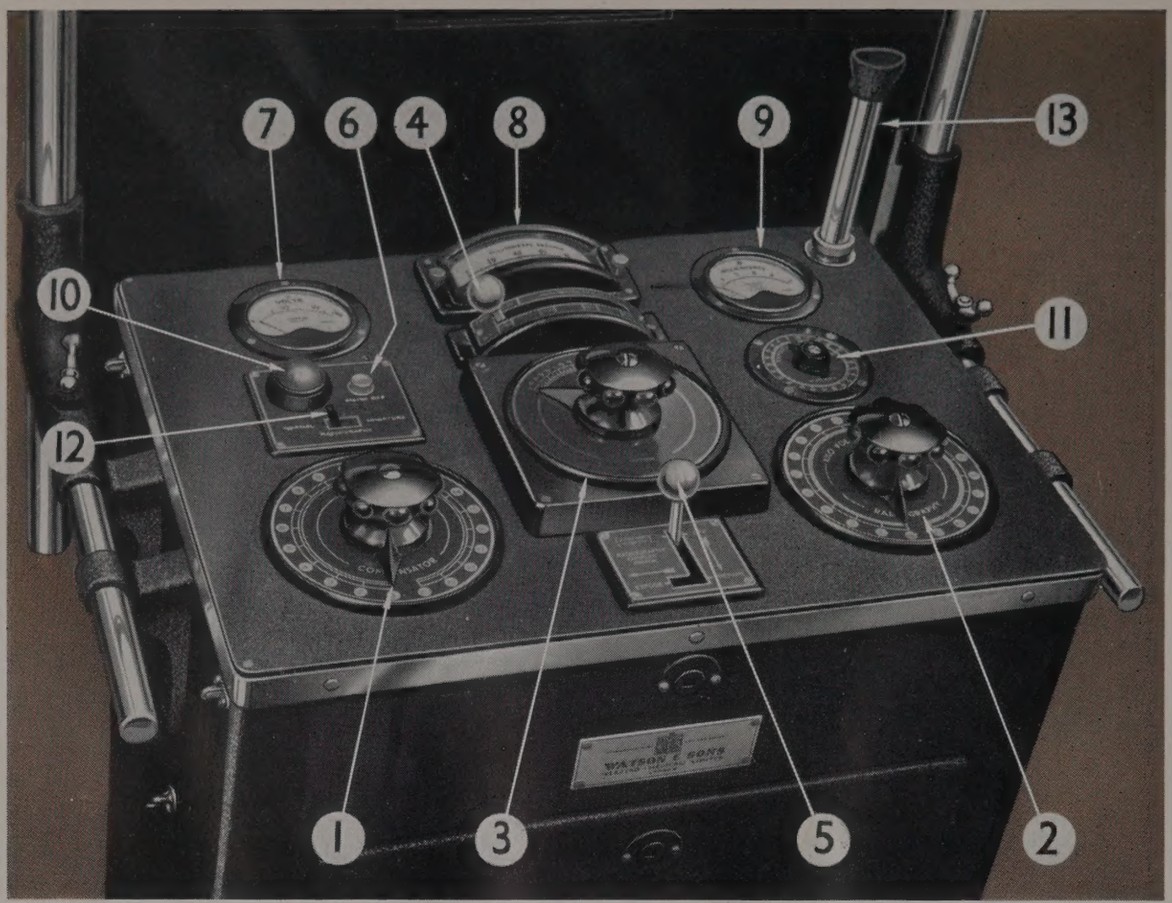
The Film Numbering Device is designed for use in conjunction with the standard examinee's record card recommended by the Ministry of Health. The card, bearing particulars of the examinee and a printed identification number, is inserted into a slot in the device at the top of the camera tunnel. The image of the number is photographically recorded at the same time as the exposure is made. The number appears at the centre lower edge of each frame sufficiently large to permit it to be read directly on the miniature film without the aid of a magnifier.

No exposure can be made unless the card is correctly in place and as a further safeguard it is not possible to make an exposure if the filament of the illuminating lamp should fail. It is thus virtually impossible for any miniature radiograph to be produced without a positive means of identifying it with the examinee.

THE CONTROL TABLE

With a view to minimising the number of adjustments necessary, and thus enabling the operator to give full attention to the examinees, the mobile control unit has been made as simple as possible from the standpoint of operation. It also incorporates various electrical interlocks which preclude any risk of loading the X-ray tube beyond its maximum safe ratings during either miniature or normal radiography.

The exposure lever has two positions—" Prepare " and " Expose ". When the lever is moved to the first position, the rotor of the rotating anode tube is energized, the tube and valve filaments become



THE CONTROL PANEL

Simplicity of operation is the keynote of the control panel. Remarkably consistent results are obtained irrespective of variations in the thickness of examinees.

1. LINE VOLTAGE COMPENSATOR CONTROL AND " MAINS ON " SWITCH. Switches on the apparatus and provides for adjustment to suit the prevailing line voltage.

2. KILOVOLTAGE CONTROL—covering a range of approximately 50 to 100 kV (peak) in 20 steps of 2.5 kV.

3. KILOWATT-SYNCHRO-TIMER—having a range of from 0.02 to 1 second, and arranged to switch on or off at a pre-determined part of any cycle, thus ensuring unfailing accuracy. This control is so interlocked with the mA control and camera circuit that it is impossible to use the high current ranges on long exposures. The maximum permissible exposure times for the selected current values are indicated by coloured bands on the dials of both controls. With phototimer operation, the normal timer serves as a safety measure.

4. MILLIAMPERAGE SELECTOR. As indicated above, this control is interlocked with the timing circuit to prevent the possibility of overloading the tube. It gives four pre-set values.

5. EXPOSURE SWITCH. When moved forward to the " prepare " position, the rotor of the rotating anode tube commences to operate. When the operator is ready to make the exposure, the control is moved to the " expose " position. If the lever is moved straight through from the " prepare " to the " exposure " position, a delay of one-and-a-half seconds will automatically elapse before the exposure is made.

6. " MAINS OFF " PRESS BUTTON—de-energises the apparatus.

7. COMPENSATOR VOLTMETER indicates, by means of red lines inscribed on the dial, when the voltage compensator control has been correctly set.

8. MILLIAMPERE-SECONDS METER—measures the product of time and current. It is reset to zero automatically by electrical means and indicates a new reading when the next exposure is made.

9. MILLIAMMETER—indicates the tube current on screening only.

10. " MAINS ON " PILOT LIGHT (red).

11. EXPOSURE COUNTER. This is set to the number of exposures required on one length of film, and rotates back to zero. A bell rings after each exposure indicating that the film has moved on.

12. MINIATURE/NORMAL CHANGEOVER SWITCH.

13. OPTICAL CENTRING DEVICE—which must be in position in the control before the exposure can be made.

heated, and the number on the examinee's identification card is photographically recorded on the film. On moving the lever to " Expose ", tension is applied to the X-ray tube and the " X-rays On " pilot is illuminated. The film is automatically moved forward in the camera by one frame when the lever is released.

PHOTO-ELECTRIC EXPOSURE TIMING

An optional feature of the apparatus is an instrument which controls automatically the exposure time and thus ensures chest radiographs of constant density irrespective of the opacity of the examinee.

The phototimer is found in practice to be a great asset because in addition to standardizing the degree of film blackening, it also speeds up the work by eliminating the need for measuring the chest thickness of each examinee.

It is necessary only to set the Kilovoltage Control to the approximate position, whilst the normal timer serves as a safeguard against the possibility of gross over exposure.

MAINTENANCE

From the outset it has been realized that for a mass radiography unit to be successful it must be thoroughly dependable. Breakdowns must be avoided at all costs.

Every reasonable precaution has therefore been taken to reduce the liability to mechanical or electrical failure to the minimum, whilst by reason of the heavy strain to which the equipment is subjected in operation, special measures have been taken to enable the operating personnel to deal with minor eventualities themselves. Very comprehensive installation and operating instructions are supplied, including a list of symptoms of possible faults and the method of rectifying them. Ready accessibility to working parts has received special attention, and number and colour codes are used throughout to facilitate the location of leads and components.

Overhaul of the apparatus at regular intervals by trained X-ray engineers is recommended as a further safeguard against interruptions to the service. Parts subject to wear will then be replaced before the fact becomes evident. Arrangements can be made for such periodical inspections to be carried out to Watson Mass Radiography Units in any part of the world.

CATALOGUE DESCRIPTION

Watson Apparatus for Mass Miniature Radiography comprising: **Generator and Tube Stand Unit** complete with " Dynamax 25 " X-Ray Tube, Shockproof Cables, four Valves, and Tube Diaphragm.

Screening and Camera Unit complete with Fluorescent Screen and Lucidex Grid. Carrying Cases containing 35 mm. Camera with f/1.5 lens, Film Marking Outfit, Optical Centring Device, Spare Exposed Film Cassette, Spare Lamps, etc.

Control Unit with metal Cover and Footswitch. **Connecting Cables**, three 12-ft. flexible cables with multiple plugs for interconnections. **Floor Track** Hinged for transport. **Protective Screens.** Two Metal Screens with Lead-glass windows. One is arranged for attachment to the control unit. *Cat. No. 317/1.*

As above with Camera for 70 mm. films. *Cat. No. 317/2.*

Phototimer for automatic control of exposures complete with Photo-cell. *Cat. No. 317/3.*

ACCESSORIES

A complete list of recommended accessories and spare parts will gladly be supplied on request. Essential items designed expressly for mass radiography are listed below.

Examinee's Record Cards. Serially numbered and printed either to the standard M.O.H. pattern or specially to suit customer's requirements. In quantities of 10,000. *Cat. No. 316/10.*

Projector for 35 mm. films complete with screen. *Cat. No. 317/20.*

Screen Holder for use with above. *Cat. No. 317/21.*

White Card Screens for use with above. In packets of 36. *Cat. No. 317/22.*

Chest Measuring Calipers. (Not essential when apparatus is equipped with phototimer). *Cat. No. 317/30.*

Processing Tanks for 35 mm. films, *Cat. No. 627/15* and Spare Spirals, *Cat. No. 627/16.*

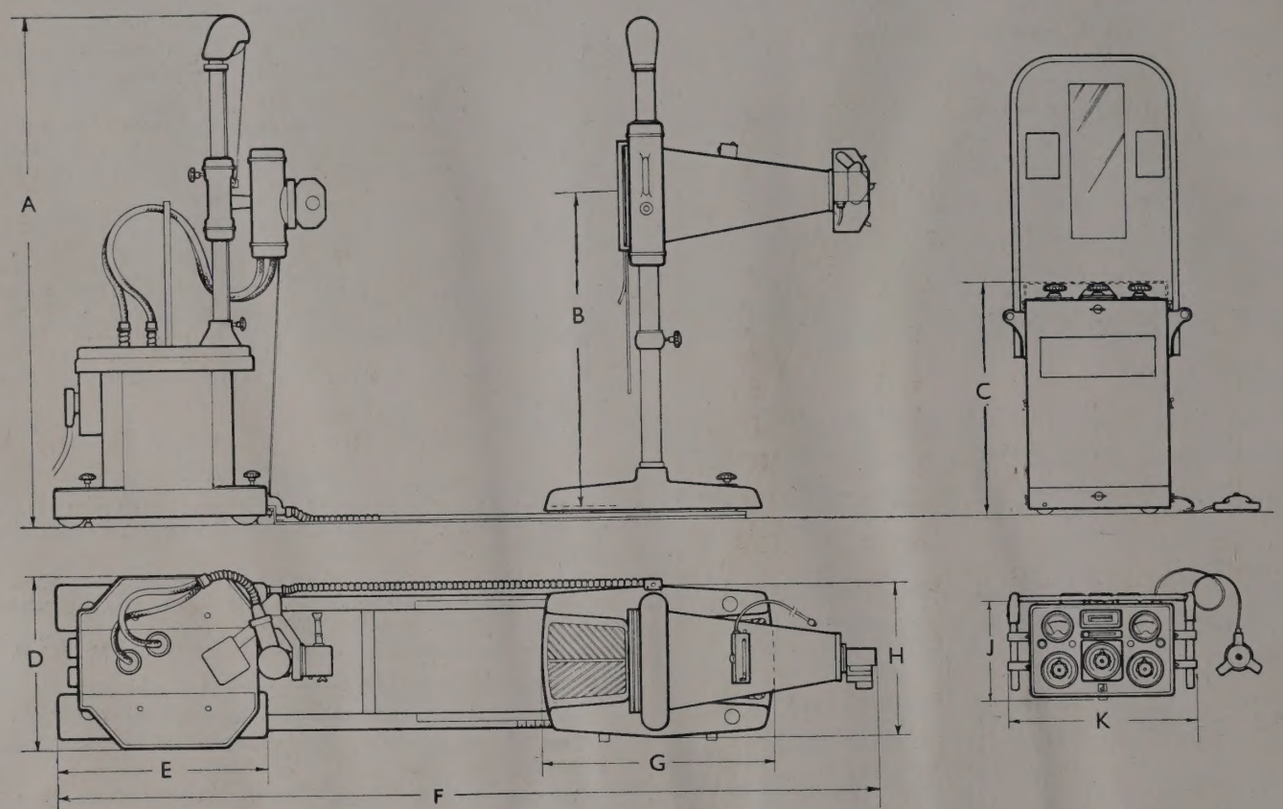
Thermometer for use in conjunction with above tanks. *Cat. No. 627/29.*

Processing Outfit for 70 mm. films including loading stand for spiral and five stainless steel tanks. *Cat. No. 317/40.*

Whilst every care is taken to ensure the accuracy of the descriptions and illustrations in this publication, Watson & Sons (Electro-Medical) Limited reserve the right to make such alterations in the design of the apparatus as they may consider to be in the interest of the customer. All orders are accepted subject to the Company's printed Conditions of Sale.

SHIPPING SPECIFICATION

	Dimensions	Nett Weight	Gross Weight
Control	3′ 0″ × 2′ 1″ × 4′ 3″ (91 × 63 × 129 cm.)	4 2 25 (239 kg.)	6 3 0 (342 kg.)
Transformer	2′ 10″ × 2′ 7″ × 3′ 4″ (86 × 78 × 101 cm.)	4 1 18 (224 kg.)	6 1 0 (317 kg.)
Base for Transformer, Base for Screening Stand, Transformer Cover	3′ 8″ × 2′ 7″ × 2′ 2″ (111 × 78 × 66 cm.)	2 3 10 (144 kg.)	4 0 2 (204 kg.)
Screening Stand, Control, Protective Screen, Operator's Protective Screen	7′ 0″ × 3′ 5″ × 1′ 7″ (213 × 104 × 48 cm.)	2 3 26 (151 kg.)	5 0 10 (258 kg.)
Tube Stand Upright, Diaphragm, Cable Support Brackets, Cables	5′ 5″ × 1′ 10″ × 1′ 5″ (165 × 55 × 43 cm.)	1 0 14 (57 kg.)	1 3 26 (100 kg.)
Apron, Track, Calipers, Camera Complete with Carrying Cases, Camera Tunnel, Footswitch, H.T. Cables, Tools, Spares, Meters, and Accessories	3′ 11″ × 2′ 11″ × 2′ 3″ (119 × 88 × 68 cm.)	2 0 8 (105 kg.)	3 1 14 (171 kg.)
Photo-timer (if ordered) ...	2′ 6″ × 1′ 7″ × 1′ 4″ (76 × 48 × 40 cm.)	0 2 0 (25 kg.)	0 3 20 (37 kg.)
Eight 5-gallon Drums of Oil	2′ 5″ × 2′ 5″ × 3′ 3″ (73 × 73 × 43 cm.)	3 2 0 (178 kg.)	4 2 10 (233 kg.)
4 Rectifying Valves ...	1′ 2″ × 1′ 2″ × 1′ 5″ (35 × 35 × 43 cm.)	0 0 6 (3 kg.)	0 0 17 (8 kg.)
Dynamax X-Ray Tube ...	1′ 7″ × 1′ 4″ × 2′ 6″ (48 × 40 × 76 cm.)	0 1 7 (15 kg.)	0 2 9 (29 kg.)
Static Balancer (if required)	2′ 1″ × 1′ 3″ × 2′ 2″ (63 × 38 × 66 cm.)	2 1 11 (119 kg.)	2 3 25 (151 kg.)



DIMENSIONS

	Ft. In.	Metres		Ft. In.	Metres		Ft. In.	Metres
A	7 3	2·21	D	2 3	0·68	G	3 1	0·94
B Min.	3 7	1·09	E	3 0	0·91	H	2 0	0·61
Max.	5 0	1·52	F at 36″ (0·91 m.) F/S	9 1	2·77	J	1 7½	0·49
C	3 3½	1·0	at 60″ (1.52 m.) F/F	11 0	3·4	K	2 6½	0·77

WATSON & SONS
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